Linking Metabolic Rates and Excretion Rates in Tropical Mayflies

By

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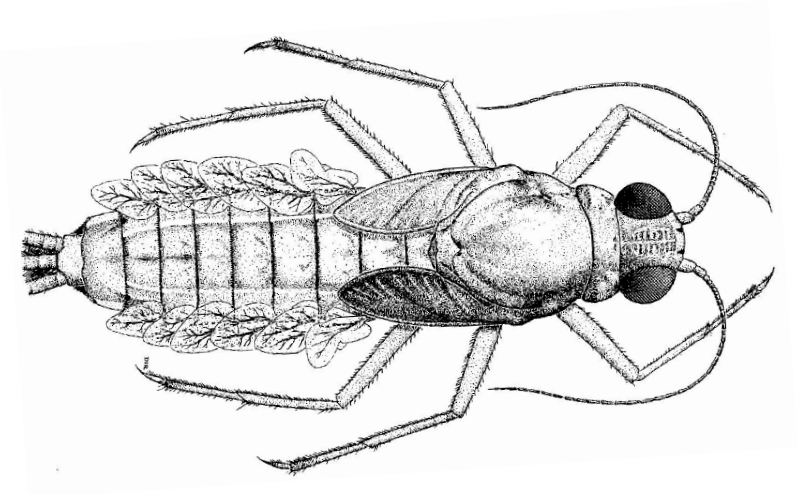
Background

- Aquatic insects make up a large part of the biomass of tropical streams.
- They play important functional roles in the stream ecosystem
- Understanding the processes that support healthy aquatic insect populations allow us to better predict how they will respond to a changing climate



Background

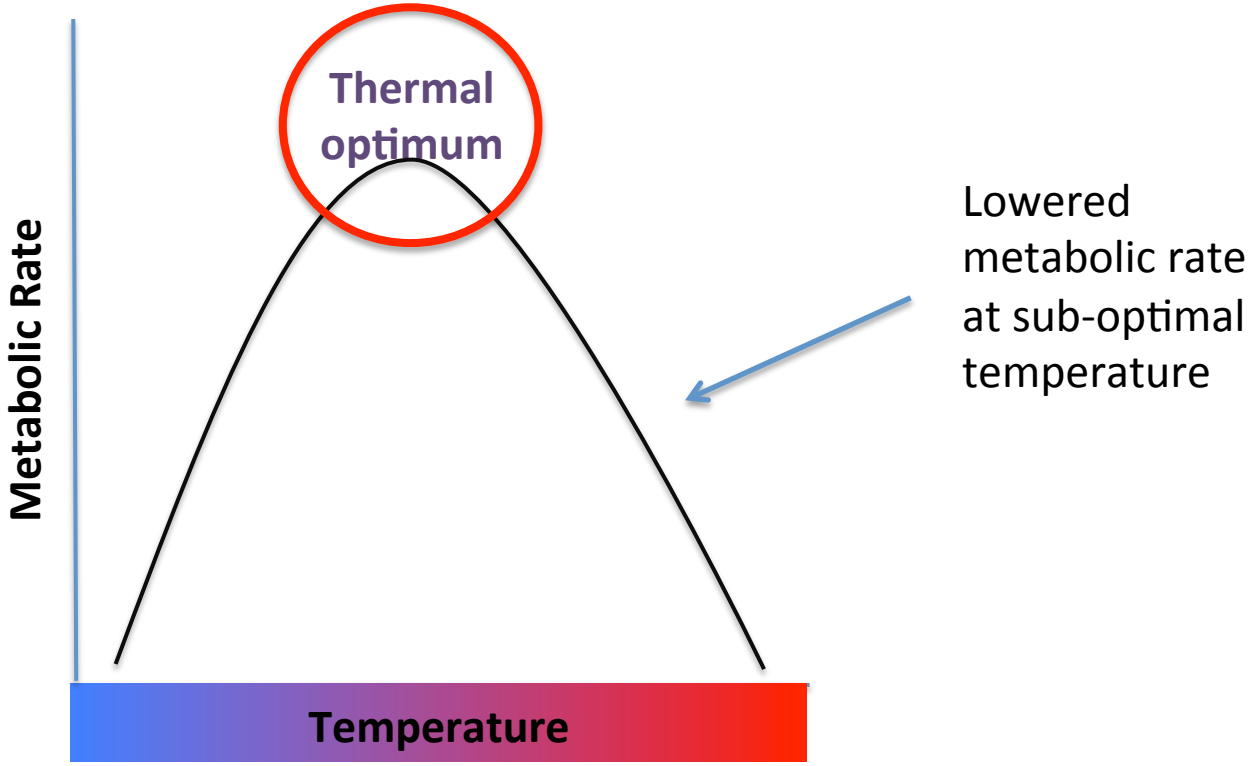
- Metabolic rate and excretion are two fundamental processes that determine the growth rate, a fitness correlate, and thus affect population size[1,2].

1. Gillooly et al. 2001 *Science* ; 2. Cummins 1973 *Annu. Rev. Entomology*

How do **metabolic rates** and **excretion rates** vary across a range of temperatures in tropical mayflies from different elevations?

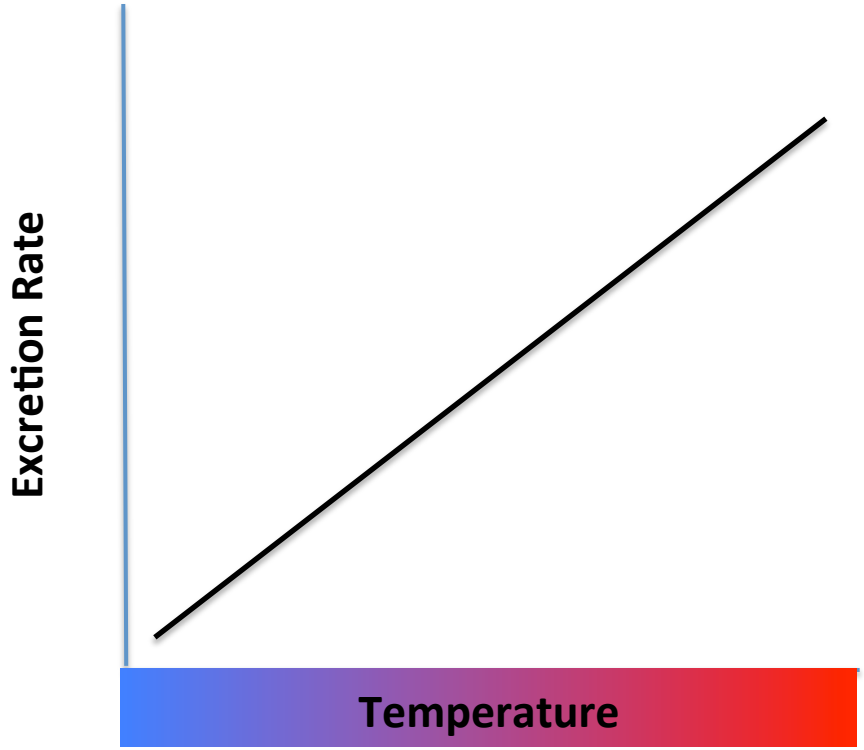
Predictions

- Metabolic rates will be highest at home stream (optimal) temperatures, but lowest at sub-optimal temperatures



Predictions

- Excretion rates will be highest at native stream temperatures but lowest at temperatures outside the native range



Study System

- Rio Papallacta drainage in Ecuador
- 3 streams
- 1847m → 4001m
- Roughly 450m apart

Study Organism

- Family Baetidae
- Genus *Andesiops*
- Widespread and abundant
- Easy to maintain in lab

Collection

A. Shah collecting mid-elevation (2700 m) in Ecuador

Acclimation

Metabolic Rate Experimental Setup

Mayfly in 4mL respirometery chamber

Excretion Rate Experiments

- We used different individuals from respiration measurements

- 60 min incubations (from 5°C to 25°C)
- Quantify NH_4 using the fluorometric method described by Holmes et al. 1999 and modified by Taylor et al. 2007

- We measured excretion using a **Turner Designs *Aqua*Fluor Handheld Fluorometer**.

Collaborators A. Shah (*above*) and A. Rugenski (*below*) measuring excretion of tropical mayflies

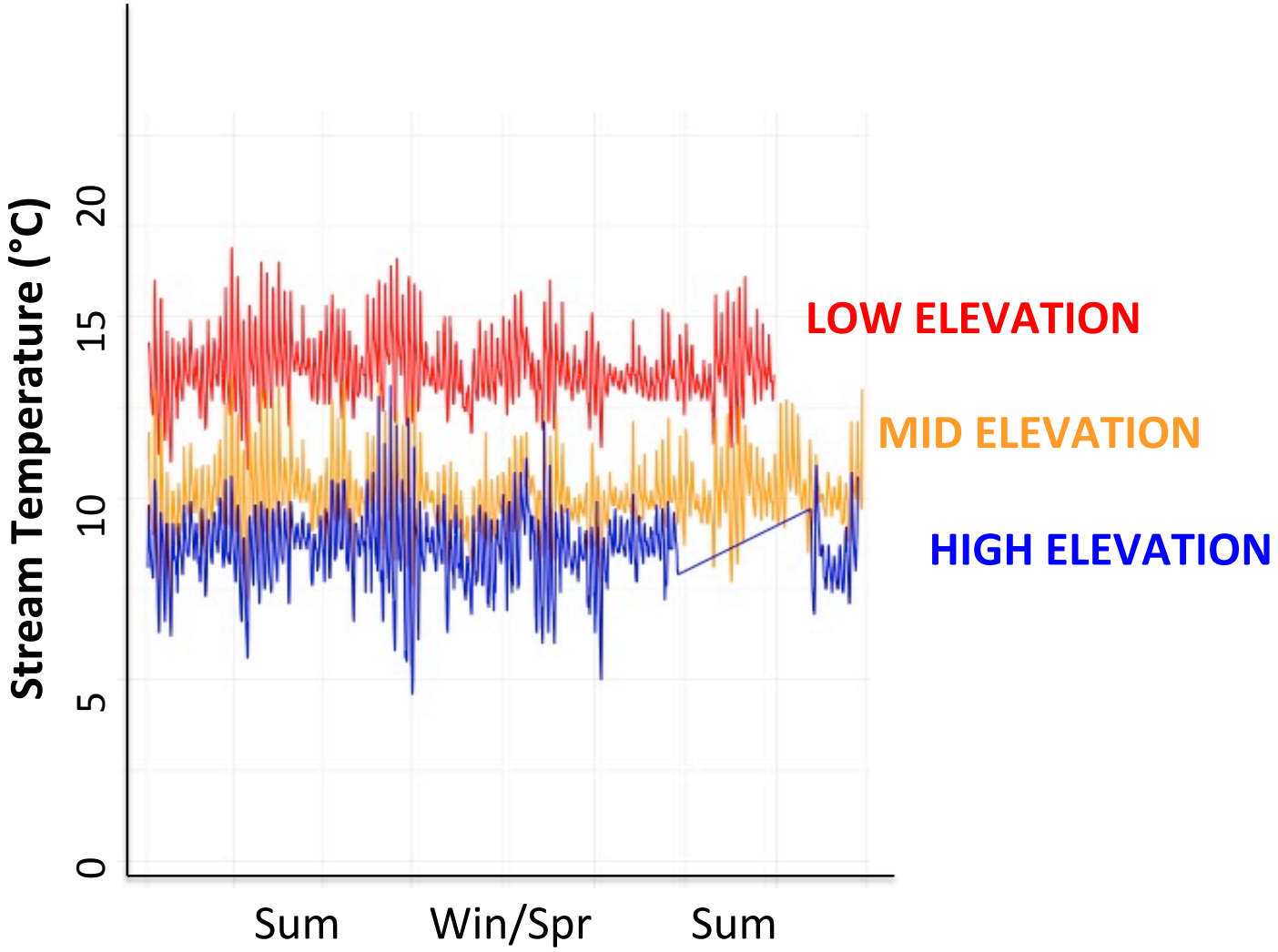
Measuring Excretion Rates

1. Incubate for 45 min

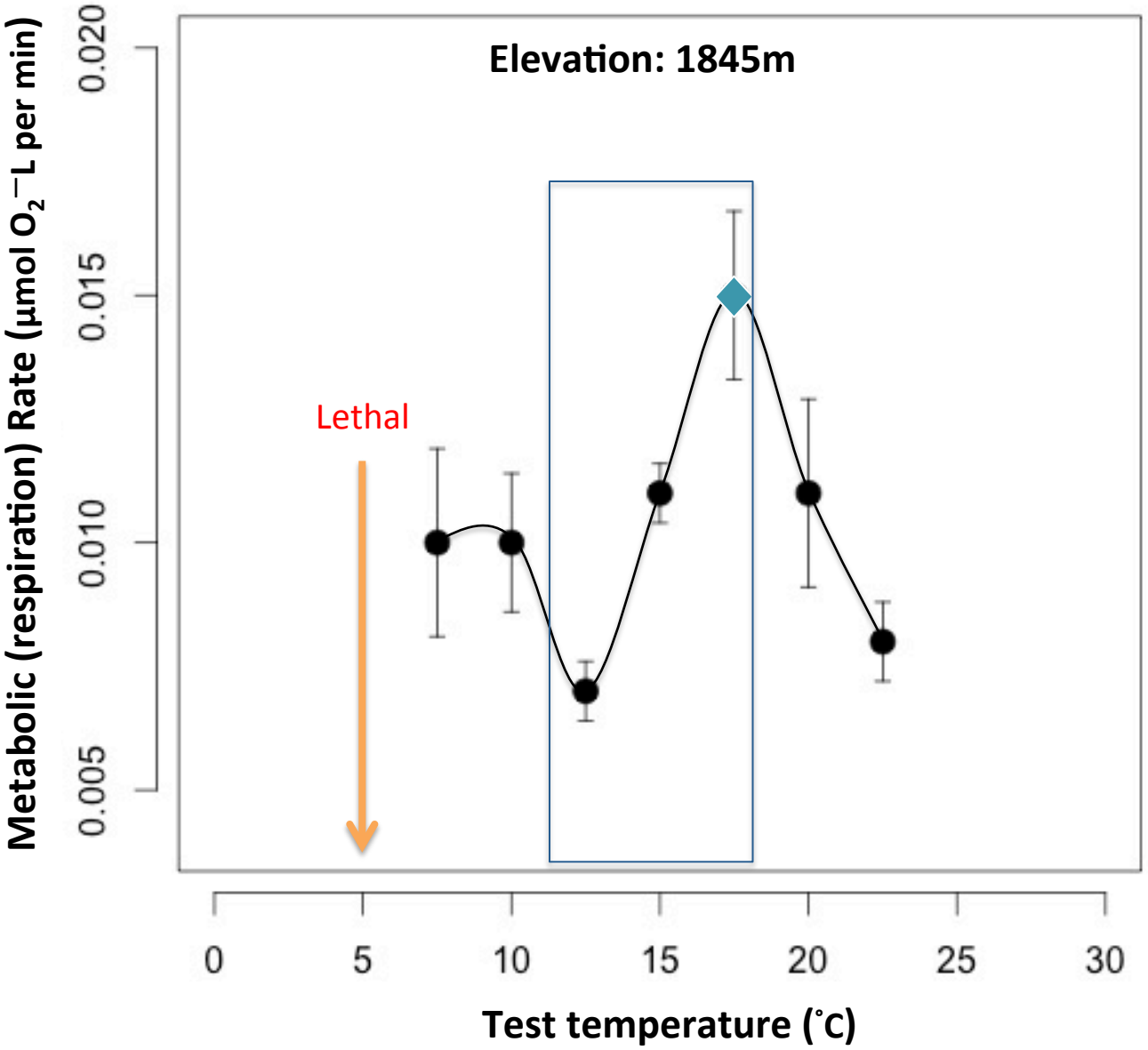
Metabolic rate and excretion measured across a range of five temperatures from 5°C to 25°C, at 5°C intervals.

2. Measure excretion

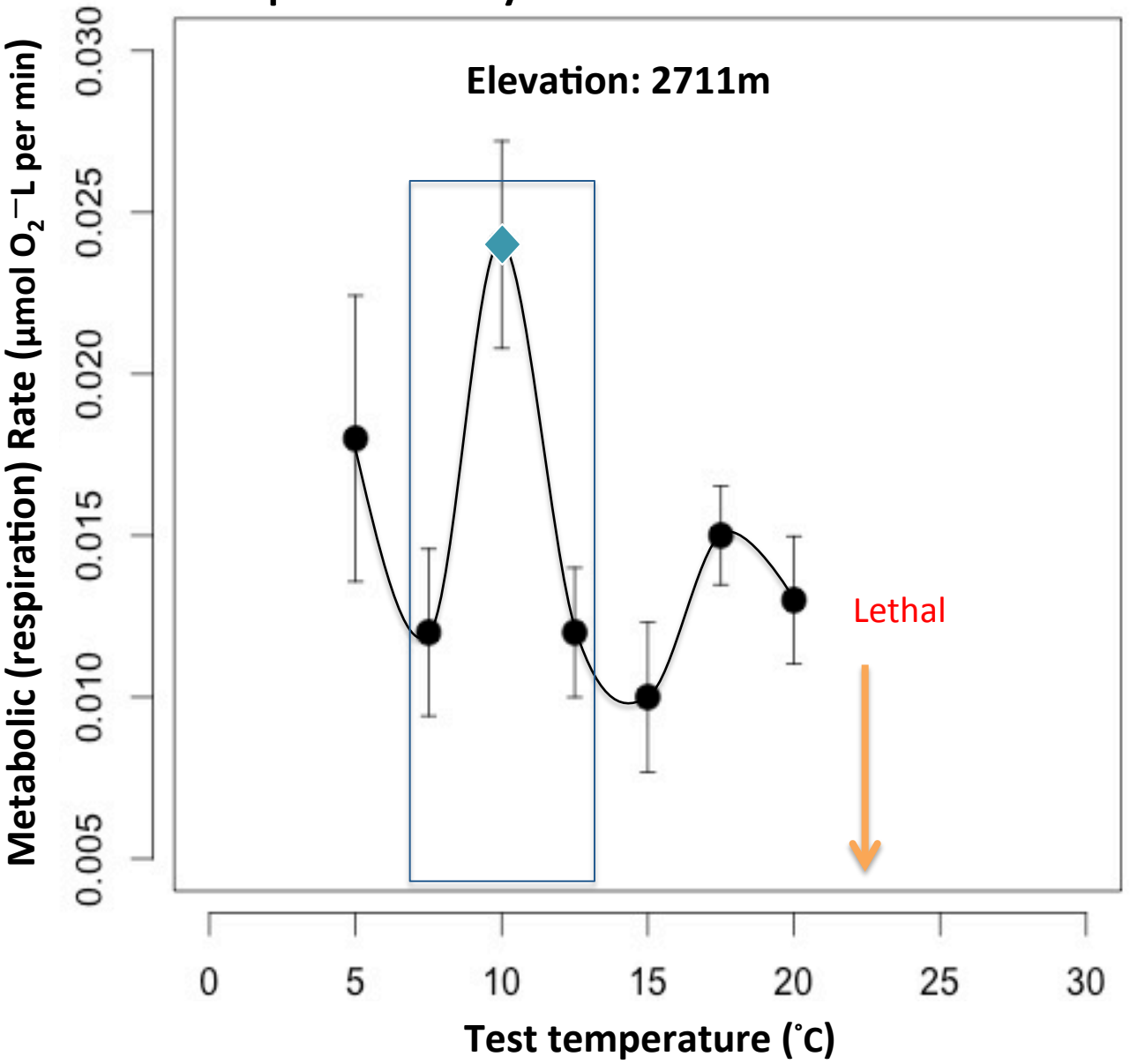
Results – Stream temperature decreases across elevation



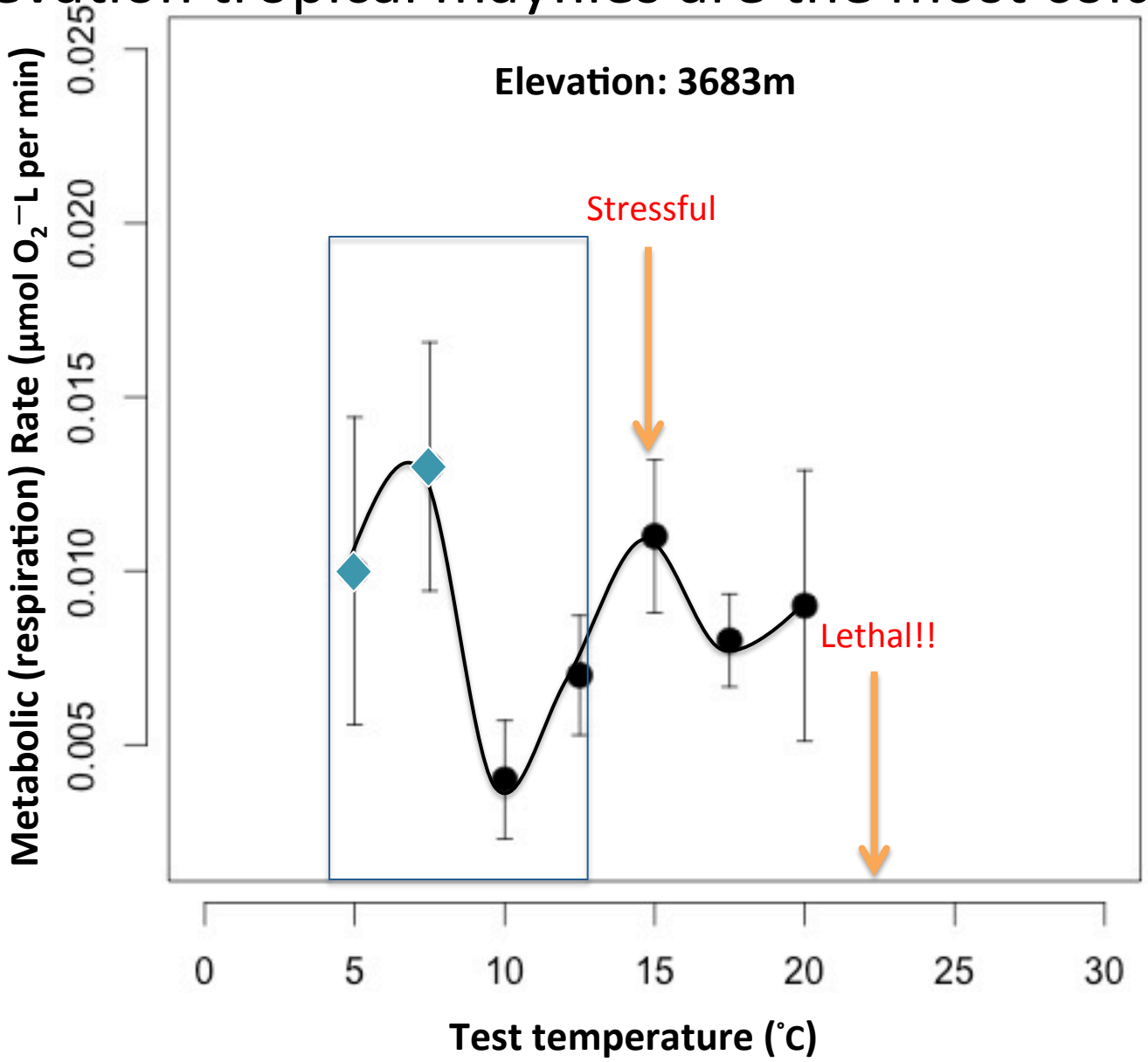
Metabolic Rate Results:
Low elevation tropical mayflies are more **warm**-tolerant



Metabolic Rate Results:
Mid elevation tropical mayflies exhibit more cold tolerance

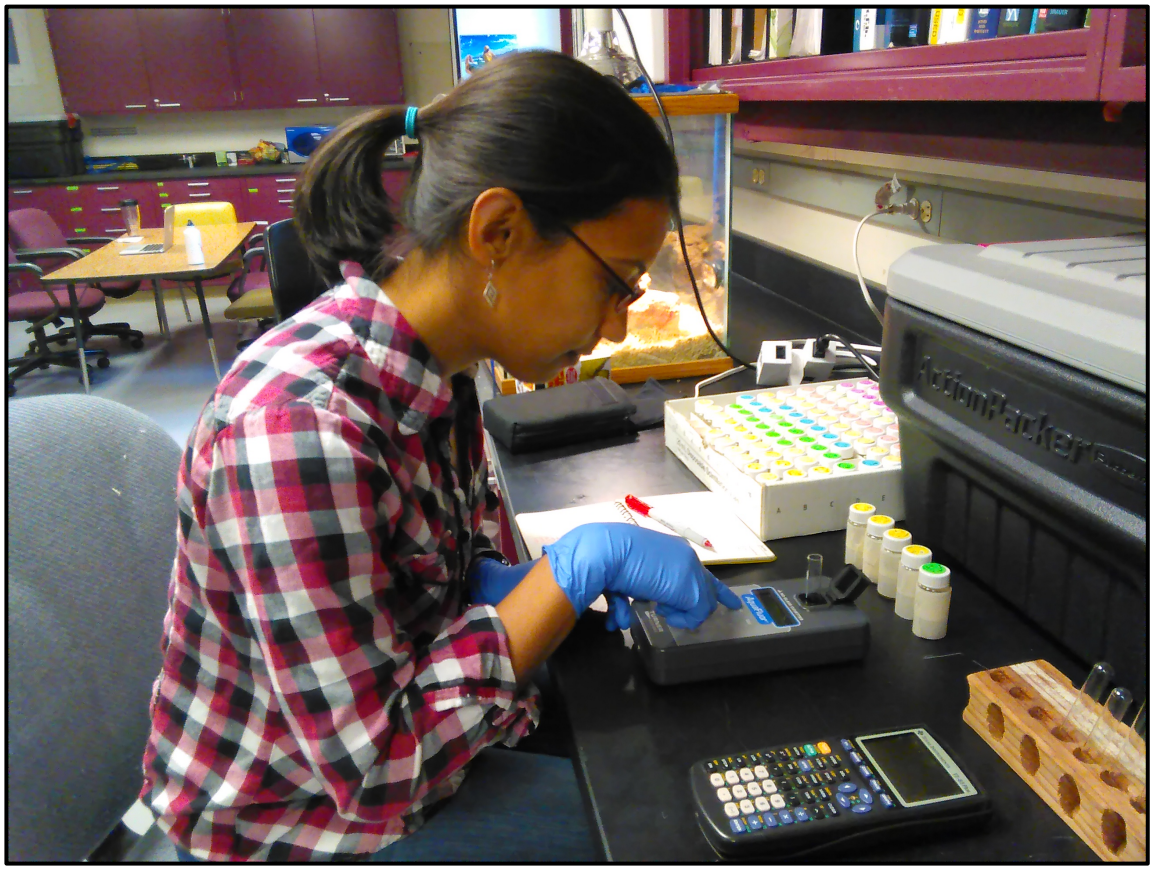


Metabolic Rate Results:
High elevation tropical mayflies are the most cold-tolerant

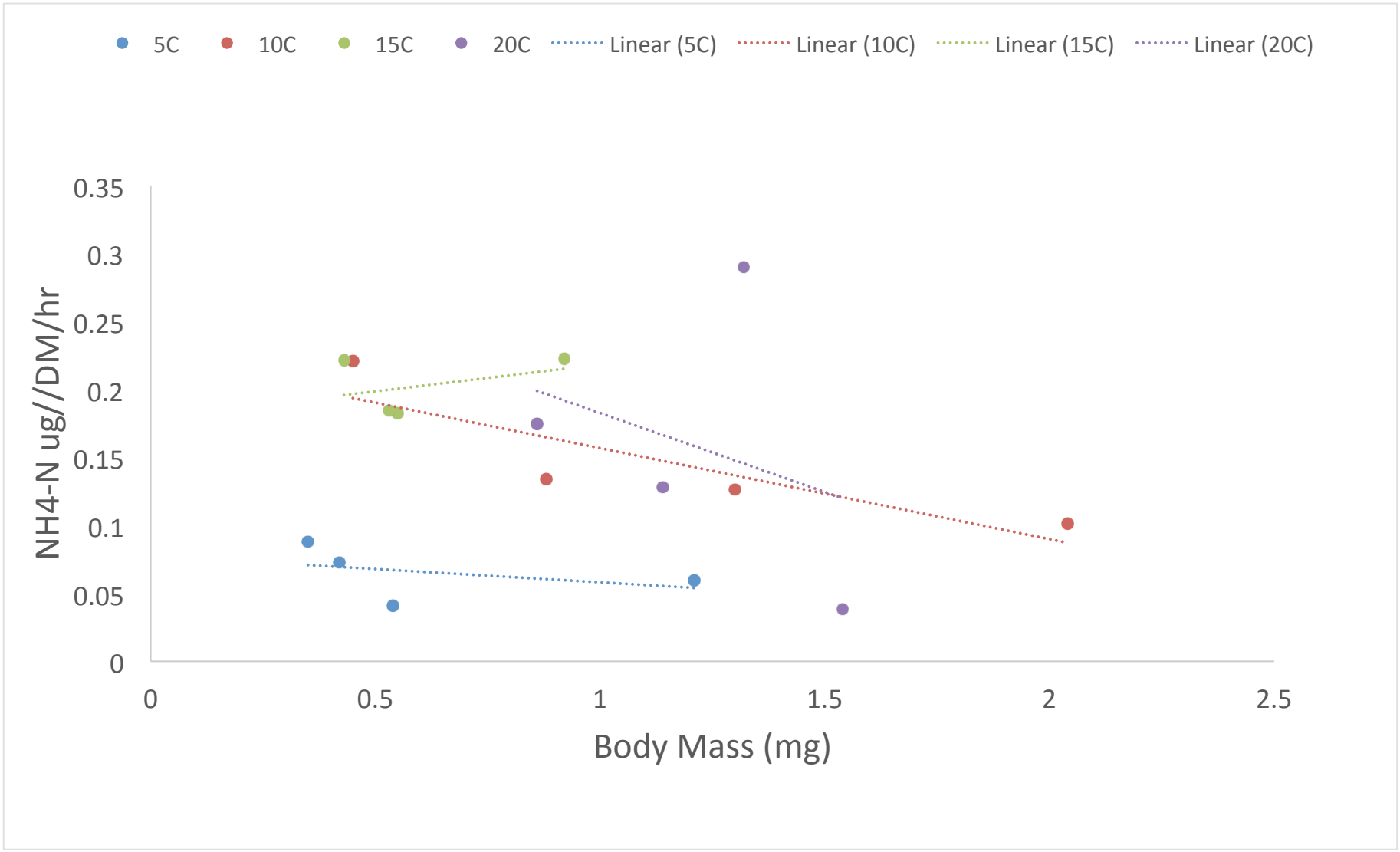


Linking excretion rates to metabolic rates in Ecuador

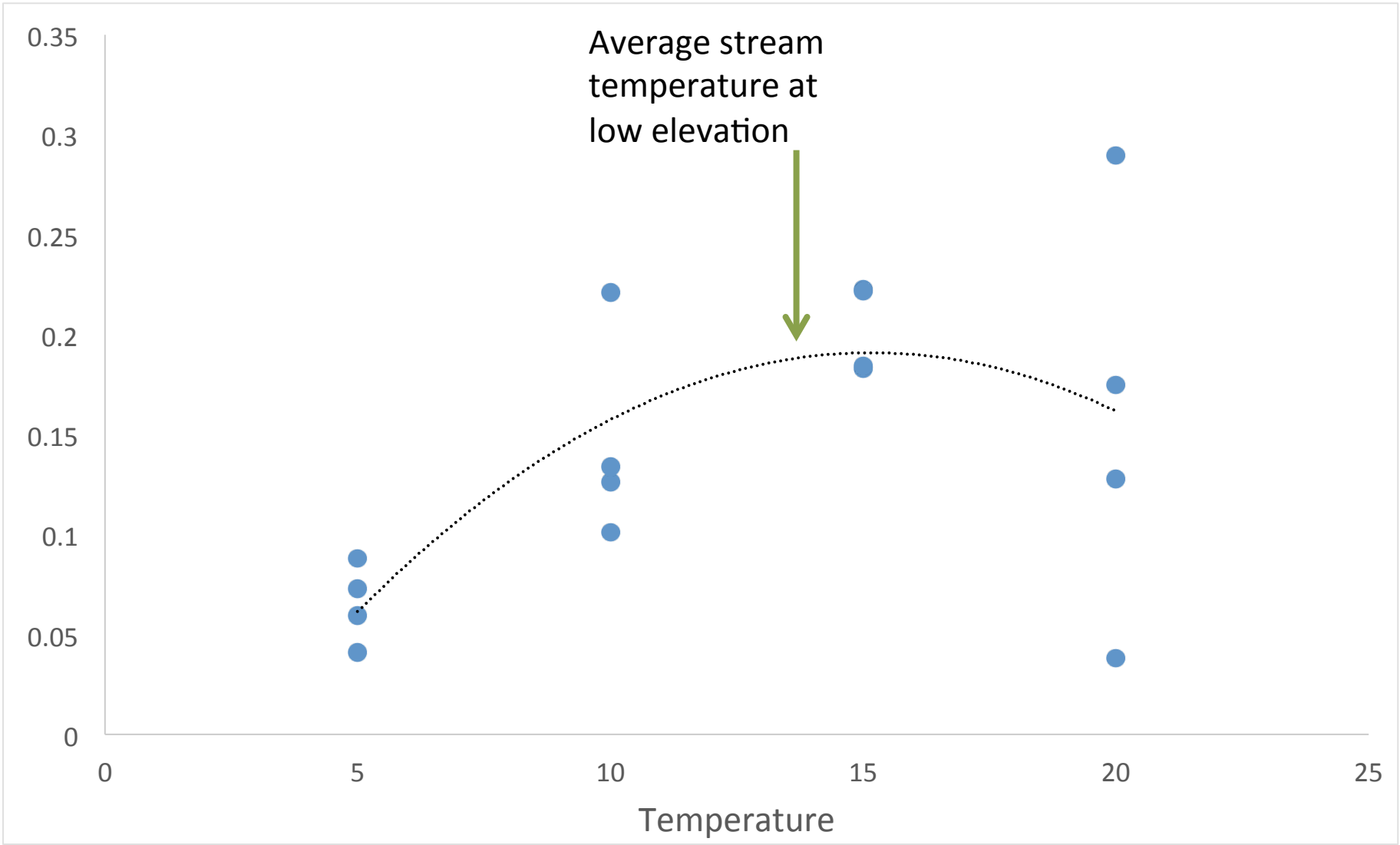
- Do excretion rates match metabolic rates?



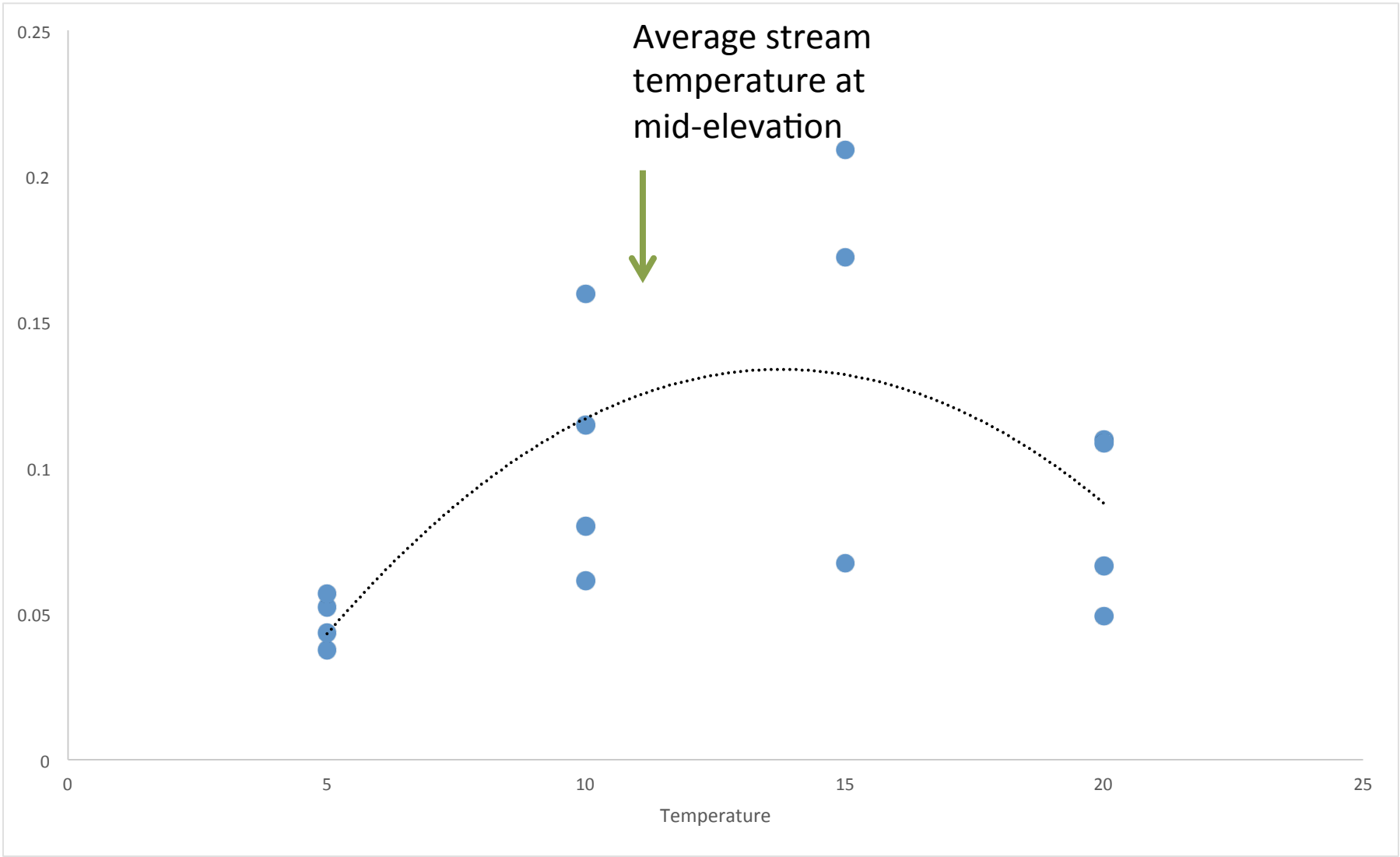
Excretion Rate Overall Results:
Larger individuals have overall lower excretion



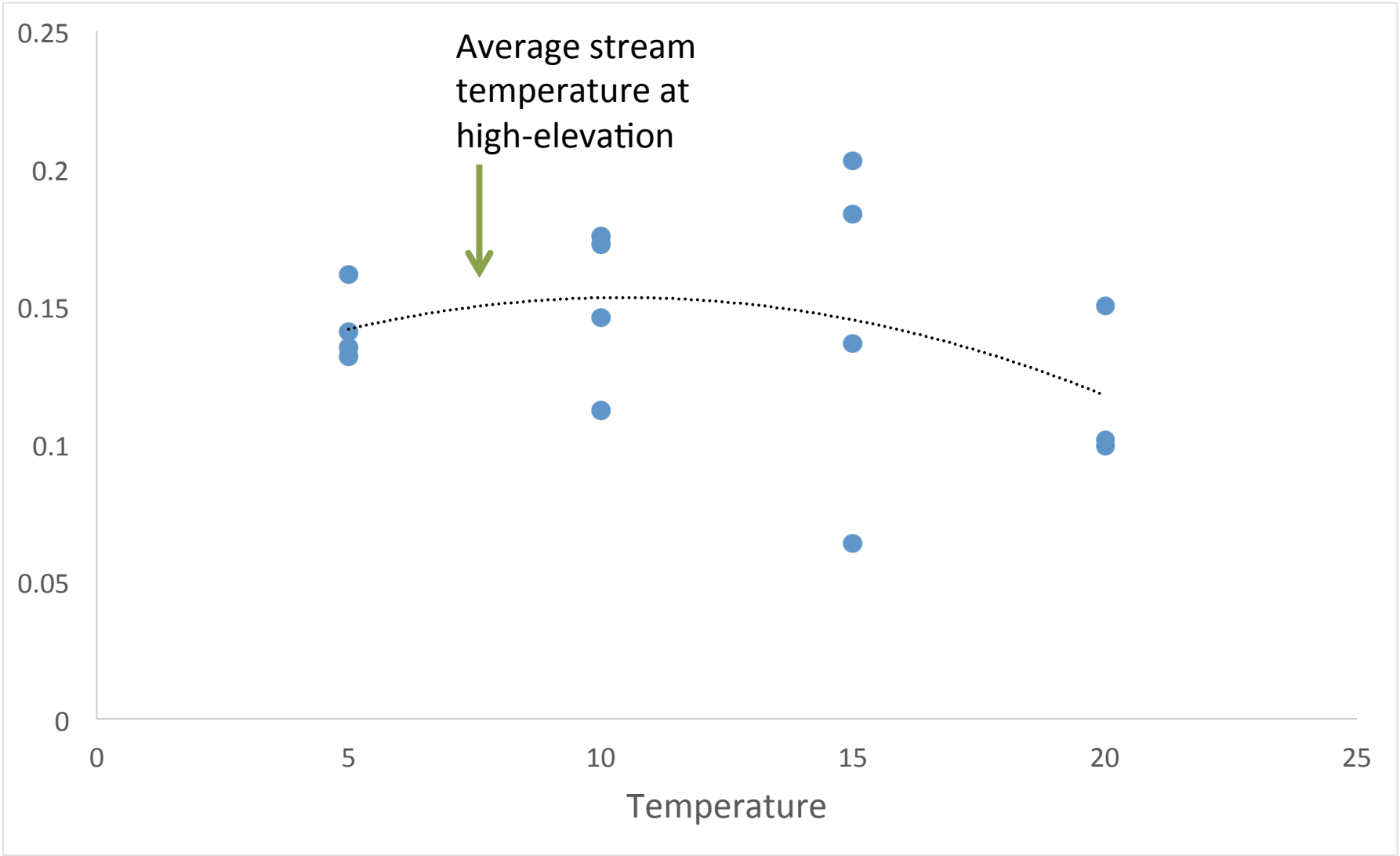
Excretion Rate Results:
Low elevation mayflies showed higher excretion at higher temperatures



Excretion Rate Results:
Mid elevation mayflies showed generally higher excretion at mid-temperatures



Excretion Rate Results:
High elevation mayflies showed higher excretion low temperatures



Upshot of metabolic rate measurements: Tropical mayflies have the highest metabolic rate (best performance) at their home stream temperature, but exhibit low metabolic rates, stress, and even mortality at too-cold or too-warm (sub-optimal) temperatures.

Upshot of excretion measurements: Similar to metabolic rate, tropical mayflies have the highest excretion rates closest to their native stream temperature

Conclusions/Implications

- Although further tests of thermal tolerance are required, these data suggest that tropical mayflies have the best performance at the temperatures they typically experience
- Thus, they are likely to be vulnerable to any major changes in their thermal environment, which could disrupt the normal functioning of important processes like metabolism and excretion.

Conclusions/Implications

- Because mayflies are some of the most abundant herbivores in tropical streams, effects of their decline will likely be seen throughout the stream ecosystem and food-web.

Acknowledgements

<u>Photo:</u> Mayfly molting in respirometery chamber

<u>Field Assistants</u>

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